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(54) Grain Treatment Method

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(72) Inventor: Omitted

(71) Applicant: Omitted

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(57) CLAIMS

1. A method for treating grain comprising: placing grain at an ambient pressure and temperature, heating the grain to a temperature near the maximum plasticizing temperature for a duration of about 1 minute to no more than 3 minutes at the ambient pressure, passing the grain between rotating rollers of a rotary mill installed at an interval of 0.05 to 0.5 mm apart immediately after the grain has reached this temperature, and returning the product obtained from the rollers to the ambient pressure and temperature.

DETAILED DESCRIPTION OF THE INVENTION

Grain at an ambient pressure is mechanically deformed by passing between mill rollers separated by a distance of about 0.05 mm, at which time the grain reaches maximum plasticity at a temperature of about 143 to 160°C and preferably 154°C.

Numerous types of treatment methods have been proposed to provide grain for use as food having high levels of nutrition and digestibility. Extensive research has also been conducted on providing nutrients to animals other than monogastric animals. These preliminary treatments are specifically intended to interact with the biochemistry of monogastric animals in order to enhance the efficacy of nutrients contained in the grain with respect to the animals. In addition, although considerable research has also been conducted on grain for use in humans and other monogastric animals, the range of unresolved fields is extremely broad.

A typical object of the present invention is to improve on a method for treating grain to improve the applicability of grain as a food for monogastric animals and to improve the ability of monogastric animals to utilize the starch present in grain in particular.

Another object of the present invention is to provide a grain treatment method capable of obtaining a nutritional form far superior with respect to digestion and use of starch in its natural form within grain by animals.

Another object of the present invention is to provide a grain treatment method that is not accompanied by heating for a long period of time in order to convert grain starch for consumption by humans and other monogastric animals.

Still another object of the present invention is to provide a method for treating grain for improving the nutritional characteristics of grain without cooking for a long period of time in water.

Still another object of the present invention is to provide a method for treating grain for improving the digestibility of the starch present in grain without using a liquid.

Another object of the present invention is to improve the nutritional characteristics and food characteristics of ordinary grains.

The method of the present invention is summarized by the following steps using husked or non-husked grain.

(a) The grain is heated to a temperature corresponding to the maximum plasticizing temperature of the grain.

(b) This heating is carried out for a comparably short period of time.

(c) This heating is carried out while maintaining the grain in a dry state.

(d) The grain is mechanically deformed by passing between a pair of rollers having

an interval of about 0.05 mm.

(e) The grain that has passed between the rollers is cooled by ordinary methods.

The following provides an explanation of the method of the present invention. Husked or non-husked grain is heated to the maximum plasticizing temperature thereof with hot dry air. This temperature differs for each type of grain depending on the individual structures of starch granules within the grain. The starch granules are granules that numerous starch molecules are typically densely gathered in a helical shape. As an effect of heating, the oscillations between starch molecules within the starch granules increase, the structure of the starch granules becomes distorted, and the granules become even more flexible, thereby causing the plasticity of the grain to increase. A comparison of the starch granules of various grains revealed that milo starch granules, for example, have the most dense tissue structure, while barley and oats have the least dense tissue structure, and wheat and corn have structures of intermediate density. It was found that grains having a starch granule structure of even higher density require an even higher temperature for achieving the maximum plasticity of that grain. Thus, it was found that the maximum plasticizing temperature of barley and oats is about 143°C, that of wheat is about 150°C, that of corn is about 154°C and that of milo is about 160°C.

Once each grain has been heated to its maximum plasticizing temperature, it is promptly inserted between a pair of rotating mill rollers installed at an interval of about 0.05 mm. When passing between these rollers, the grain is deformed by its plasticization and takes on a new form without being substantially ground or crushed. For this reason, there is no generation of undesirable fine particles. The rollers themselves are preferably also heated to and maintained at a temperature suitable for the grain. This is because it is important to maintain maximum plasticity while the grain is rolled between the rollers. During the time the thermoplastic grain passes between the rollers, the structure of the starch granules within the grain is destroyed by strict flattening attributable to the rolling so that the structure does not return to the original dense, typically helical structure during subsequent cooling. The destroyed structure of the starch granules is easier to digest because it is more easily hydrated, is more susceptible to attack by animal digestive enzymes, and leads to the formation of simpler and more easily digestible compounds in the manner of glucose resulting from

hydrolysis of the starch. In this manner, the effect of this method lies in the formation of easily digestible products resulting from destruction of the starch granules within grain. After rolling, the grain is cooled to the ambient temperature.

As an example of the method of the present invention, whole wheat was heated to 150°C for 90 seconds. This was then passed between rollers having an interval of 0.05 mm. Next, the wheat treated in this manner was tested with respect to untreated wheat to determine the rate of increase in digestibility attributable to the method of the present invention. According to this test, the treated wheat was found to demonstrate an 89% increase in digestibility as compared with the untreated wheat.

As described in volume 41, no. 2, page 26 of "Foodstuffs" published on January 11, 1969, the test procedure used to make this determination includes a comparison between treated grain and finely crushed untreated grain. The grain sample to be tested is incubated for 30 minutes at a temperature of 40°C at a ratio of 1 g of grain sample to 250 mg of pancreatic enzyme used as a typical digestive enzyme of monogastric animals (porcine pancreatic enzyme, using N.F. standards). The result was a colored compound, and this colored compound was subjected to spectrophotometric analysis to determine the degree of hydrolysis of the sample in a direct correlative relationship with the digestibility of the grain sample. Thus, as a result of this test, the digestibility of the treated grain was determined to be greater than that of untreated grain.

With respect to changes in the factor of the grain heating temperature in the method of the present invention, based on the results of a test using wheat grain at a heating temperature of other than 150°C while maintaining the interval between rollers at 0.05 mm and the heating time at 90 seconds, wheat treated at 160°C was found to demonstrate an 89% increase in digestibility, wheat treated at 143°C was found to demonstrate an 84% increase, wheat treated at 132°C was found to demonstrate a 71% increase, and wheat treated at 118°C was found to demonstrate a 56% increase in digestibility as compared with untreated wheat. As indicated by these results, in the case of a heating temperature near the maximum plasticizing temperature, the increase in grain digestibility only changes slightly. More specifically, data from the aforementioned report on wheat indicates that the change in increased digestibility is only 5% in the case of a temperature range of 143 to 160°C. This slight change in

increases in grain digestibility in the case of a temperature near the maximum plasticizing temperature is typical of grains, and is due to the similarity of starch granules within the grain. Thus, a satisfactory example of the present invention can be demonstrated in the case of the grain heating temperature being maintained at 143 to 160°C, and preferably about 154°C, regardless of the selected grain.

If there is a substantial decrease in the initial heating temperature, in addition to the decrease in digestibility as indicated in the aforementioned wheat test data, grain plasticity has also been found to decrease significantly. If the plasticity is sufficiently low, the grain ends up being crushed when rolled. This brings about a result in which, rather than comparatively large discrete grains having a rounded or flattened, smooth shape, there is a larger proportion of grains having an undesirable, narrow and rectangular shape, thus making this undesirable.

In the case of using a temperature higher than 160°C, the grain becomes overcooked and discolored, and has poor flavor and taste. At a temperature much higher than 160°C, the plasticity again decreases and grindability increases as a matter of practice. This is most likely due to a substantial release of moisture from the grain. Moreover, treatment at a temperature sufficiently higher than the aforementioned temperature range causes greater susceptibility to the occurrence of undesirable roasting or caramelization of the grain, resulting in generally undesirable flavor for most people . In addition, at substantially higher temperatures, digestibility tends to decrease, and this is thought to be due to the formation of pyrodextrin. In the case of milo grains, if the temperature range substantially exceeds the aforementioned range, the waxy coating of the milo grains melts, which can cause aggregation and impair the treatment process.

With respect to changes in the factor of heating time in the method of the present invention, the required time for this heating under ordinary conditions varies according to several factors including the starting temperature of the grain, grain moisture content and grain size. In general, if the heating time is less than one minute, the heat is not uniformly distributed throughout the grain. This results in non-uniform plasticity within the grain, and tends to cause an increase in grain grindability. A higher moisture content in the grain requires an even longer duration of heating to achieve a suitable treatment temperature. This is because excess moisture must be released prior to the temperature rising so that the grain temperature approaches the

maximum plasticizing temperature required for the next treatment. Grains having a large size in the manner of corn tend to require an even longer heating time because a greater amount of time is required for the heat to uniformly pass through the large grains. However, in the case of a heating time of longer than three minutes, all of the grains become overcooked, resulting in poor flavor and increased susceptibility to crushing.

With respect to the requirement of the grain being heated in a dry state, boiled or steam-heated grain does not reach the desired maximum plasticizing temperature range prior to rolling. In addition, wet-heated grain tends to aggregate easily, and this tends to impair treatment both before and after rolling. Moreover, if grain is treated with the husk still attached, it is not easy to separate the husk from the wet-heated grain, causing undesirable components to remain in the rolled finished product.

With respect to changes in the factor of roller interval in the method of the present invention, according to a test on wheat carried out at about 154°C while changing the roller interval, there was found to be no substantial detrimental effect on product digestibility until the interval exceeded about 0.5 mm. The reduction in digestibility at a roller interval in excess of about 0.5 mm was thought to be due to the combination of two factors. The first is that the starch granules within the grain are subjected to less destruction at a greater roller interval, while the second factor is that the rolled grain surface area subjected to attack by digestive enzymes is reduced at a larger roller interval. This is because the final grain product is not flat in the case of being rolled at a roller interval of 0.05 mm.

Individual examples of the effects of the method of the present invention for grains other than wheat are as described below.

Corn grain was heated for 90 seconds at 154°C and passed between rollers having an interval of 0.05 mm. Use of the test procedure described above revealed that treated corn demonstrated a 92% increase in digestibility as compared with untreated corn.

Milo grain was heated for 90 seconds at 154°C and passed between rollers having an interval of 0.05 mm. Use of the test procedure described above revealed that treated milo demonstrated an 87% increase in digestibility as compared with untreated milo.

Barley grain was heated for 90 seconds at 154°C and passed between rollers having an interval of 0.05 mm. Use of the test procedure described above revealed that treated barley demonstrated a 100% increase in digestibility as compared with untreated barley.

As a result of the aforementioned process, dry grain products for consumption by monogastric animals are able to be produced using extremely short heating and roller treatment times at a suitable temperature without having to moisten the grain or carrying out a boiling procedure for a long period of time, and the resulting dry grain products have substantially increased digestibility.

The present invention can be summarized in the manner described below in addition to that described in the claim.

(1) The method described in the claim wherein the heating temperature is about 154°C.

(2) The method described in the claim wherein the temperature of the rollers is at a temperature close to the temperature of the grain.

(3) The method described in the claim wherein the grain is passed through the rollers immediately after having reached a temperature of 143 to 160°C.

(4) The method described in the claim wherein the grain is subjected to mechanical deformation while it is substantially at the maximum plasticizing temperature thereof.

(56) Cited Document: Japanese Patent No. 27673